

APPARATUS AND METHOD FOR SHARED NETWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

- This application is related to application entitled "METHOD AND APPARATUS FOR ROUTING MESSAGES IN A NETWORK," Motorola case number CS23238RL, filed on even date herewith and commonly assigned to the assignee of the present application and which is hereby incorporated by reference.
- This application is also related to application entitled "METHOD FOR SELECTING A CORE A NETWORK," Motorola case number CS23737RL, filed on even date herewith and commonly assigned to the assignee of the present application and which is hereby incorporated by reference.

- This application is also related to application entitled "WIRELESS ACCESS NETWORK SHARING AMONG CORE NETWORKS AND METHODS," Motorola case number CS23738RL, filed on even date herewith and commonly assigned to the assignee of the present application and which is hereby incorporated by reference.

FIELD OF THE INVENTION

The present disclosure is directed to apparatus and methods for supporting operation in a shared network.

BACKGROUND OF THE INVENTION

Presently, communication systems generally include a network operator serving user devices through a dedicated access network. For example, wireless communication systems in general comprise a Radio Access Network (RAN) and a core network (CN). The RAN includes base stations and associated radio network controllers providing wireless communication links with user device (UD), also referred to herein as user equipment (UE). The core network receives messages from the public switched telephone network (PSTN), other mobile stations, the internet, other core networks, and other network entities. The wireless communication system is coupled to other wireless communications systems, but each respective system typically operated by one operator or carrier. Such systems are currently used for landline, such as cable and twisted wire pair systems, and wireless systems such as

Global System for Mobile communication (GSM), other time division multiple access (TDMA) systems, and code divisions multiple access (CDMA) networks for example.

In the case of wireless systems, although each system operator generally uses one type of system, e.g., either CDMA, wideband CDMA (WCDMA) or TDMA, operators may operate multiple systems in a geographic area in an effort to use legacy systems to insure full coverage. For example, an operator may have an analog system and a CDMA system, or an analog system and a TDMA system, or a TDMA system and third-generation system. Additionally, a number of operators may cover the same geographic area, each operator using their own network. Each wireless communication system operates in an assigned frequency band, also called a spectrum, as there are only a finite number of available bands. However, with the current systems the system operator links the RAN to a single core network. The RAN broadcasts a message that includes identifiers for the core network coupled to the RAN, such as a PLMN, location areas and routing areas for the core network, and the like. With such dedicated systems, the RAN can serve only a single core network.

It is desirable for communication systems to allow network operators to share resources. One example of a shared network resource is twisted wire connections and cables connected to residences and offices. This infrastructure is already installed, expensive to replace, and is available to multiple operators if the network owner desires resource sharing. Another example of a network that can be shared is the radio access network where it may be desirable to share resources by allowing multiple core networks, operated for example by different operators, to connect to users through a shared radio network controller (RNC) and its associated base stations. This allows multiple network operators to access subscribers using the same spectrum, and through the same radio access network. For example, a license holder of a particular spectrum may want to sell access via their radio access network to other network operators to offset the cost of the system, while operators who do not have a spectrum license in a geographical area may want to buy access to that spectrum from the license holder.

An additional challenge in wireless systems, such as the emerging universal mobile telephone system (UMTS), to accommodate circuit switched and packet switched data. The routing of messages to one of many core networks is limited by

the basis of core network domain type, i.e. packet switched or circuit switched, and not by system operator, as only one system operator uses the radio network and the core network for both circuit switch and packet switched communications.

Thus, there is a need for a method of uniquely supporting a plurality of user
5 devices using different core networks accessed through a single shared access
network.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention will be described with
reference to the following figures, wherein like numerals in different figures designate
10 like elements and which embodiments are provided to illustrate various principles and
advantages of the invention defined by the claims, and wherein:

FIG. 1 is a diagram illustrating an exemplary wireless communication system;

FIG. 2 is a circuit schematic in block diagram form illustrating an exemplary
user device communication link;

15 FIG. 3 is a diagram illustrating an exemplary operation of a user device;

FIG. 4 is a circuit schematic in block diagram form illustrating an exemplary
embodiment of a network element;

FIG. 5 is a flow chart illustrating an exemplary operation of a network
element;

20 FIG. 6 is a diagram illustrating an exemplary wireless communication system;

FIG. 7 is a flow chart illustrating an location identification in a user device;
and

FIG. 8 is a flow chart illustrating an exemplary message routing operation of
the user device.

25 **DETAILED DESCRIPTION OF THE DRAWINGS**

Existing shared networks are not able to accommodate multiple core networks
where the user devices need to be uniquely controlled for respective core network
operators. It is a challenge to accommodate different desired behaviors for different
operators with a shared network. For example, existing radio access networks are
30 dedicated to a single operator, and thus establish that operator's desired behaviors
from the user devices connected in the system. Where operators have different
desired behaviors, the existing system is not able to accommodate different messaging

protocols for each user device for the particular operator. An additional problem is providing different location identifiers through a single access network.

The core network and access network can be wireless (wide area network and local area network) or hard-wired (twisted wire or coaxial cable). Wireless, can be UMTS, GSM, and CDMA, wire line, circuit switched and packet switch, telephone and cable. The communication systems of interest are those that facilitate voice or data or messaging services over one or more networks. Examples of two-way systems include cable, land-line, wireless cellular systems, which use analog, CDMA, and TDMA technology, and are known as GSM and Universal Mobile

10 Telecommunication Service (UMTS), 1 G, 2 G, 2.5 G, 3 G, 4 G and beyond systems (where G refers to generation) and variants or evolutions thereof. Furthermore, the systems may be wide area networks, local area networks, or combinations thereof, and the user devices of interest can support short-range communications, long-range communications, or both long and short-range communications. Examples of short range communications include cordless communications systems, pico-networks, wired or wireless LAN systems such as those supporting IEEE 802.11 standard, Blue tooth connections, and the like. Such systems preferably utilize CDMA, frequency hopping, or TDMA access technologies and one or more of various networking protocols, such as TCP/IP (Transmission Control Protocol/Internet Protocol),

15 IPX/SPX (Inter-Packet Exchange/Sequential Packet Exchange), Net BIOS (Network Basic Input Output System), or integrated digital enhanced network (iDEN™) protocol. Such systems may support trunk or dispatch functions, direct individual or group calling, and support circuit switched, Internet or other connections.

20 User devices in such systems may include wired telephones, cellular telephones, cordless telephones, so-called internet or internet protocol phones, modems, routers, access points, computers, personal digital assistants, palm top devices, and variations and evolutions thereof.

25 The instant disclosure includes exemplary devices, systems, and methods, which disclose various embodiments. However, the structure and function disclosed is not intended to limit the invention, but rather to enhance an understanding and appreciation for the inventive principles and advantages. The invention is limited solely by the claims.

Terms used in the specification and claims may be associated by those skilled in the art with terminology appearing in a particular standard, such as CDMA, GSM or 802.11 standards, or such terminology may not appear in a particular standard. Association with a standard is not intended to limit the invention to a particular standard, and variances with the language in a standard does not preclude the invention from applying to such standard. Rather, the terms used are provided solely for the purpose of explaining the illustrated examples without unduly burdening the specification with multiple explanations to accommodate language variations with all possible standards, systems, and networks. It is further understood that the use of relational terms, if any, such as first and second, top and bottom, and the like are used solely to distinguish elements or actions without necessarily requiring or implying any actual such relationship or order between such entities or actions.

Those skilled in the art will recognize that the inventive functionality and many of the inventive principles may be implemented using software programs, hardware circuits such as integrated circuits (ICs), programmable logic devices, or a combination thereof. It is expected that one of ordinary skill, notwithstanding the amount of effort required and the many design choices driven by available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating and selecting such software programs and/or ICs with minimal experimentation. In the interest of brevity and minimization of any risk of obscuring the principles and concepts according to the present invention, further discussion of such software and ICs, if any, will be limited to the essentials with respect to the principles and concepts used by the preferred embodiments.

With reference now to FIG. 1, an exemplary communication system, which is wireless communication system 100 (FIG. 1). The system 100 includes a radio network controller (RNC) 102 and an RNC 103, base stations 104-108, mobile switching center (MSC) A 114 and MSC B 115, Serving GPRS Support Node (SGSN) A 117 and SGSN B 118, and user devices (UD) 109-111. The RNCs 102 and 103 and the base stations 104-108 are a radio access network (RAN) in system 100. Core Network A 125 includes MSC A and SGSN A coupled to the RAN and to other entities, such as the public switch telephone network 140 and the Internet 142. Core

network B 126 includes MSC B and SGSN B coupled to the RAN and to other entities, such as the public switch telephone network 140 and the Internet 142.

Each of the core networks 125, 126 is associated with, for example, a different network operator and supports the network operator's connectivity, including billing, supervision, and feature support, and represents physical circuitry, software, and system functionality. Those skilled in the art will recognize that core networks can include other network entities, which may be software, hardware and/or functional in nature. In the exemplary system, the circuit switched interface to the public switched telephone network is via the MSC 114, 115 and packet switched interface to the internet is via the SGSN 116, 117. Other connectivity paths may be supported. Information exchanged between a particular user device and the core network is routed appropriately via the radio access network. Additionally, although the exemplary embodiment shown in FIG. 1 includes only two core networks, it will be understood by those skilled in the art that a plurality of core networks may be coupled to a single, shared RAN. It will be recognized by those skilled in the art that a core network can be associated with a network operator, and that a shared network is an access network used to access subscribers, or user devices, by multiple core networks. For example, a shared radio access network may have elements such as base stations and radio network controllers that respectively provide connectivity to more than one network operator, and further that the shared radio access network may support multiple user device behaviors unique to each network operator through a single base station and radio network controller.

The base stations 104-108 transmit acceptance messages and broadcast messages. Acceptance messages refer to initial messages including a rule set for a user device, and may for example be a registration accept message such as the location update accept message used in GSM systems. A broadcast message is a message transmitted by the to user devices and responsive to which user devices are expected to exhibit a desired behavior. Such behavior may include performing an operation or refraining from performing an operation.

The system 100 includes exemplary local area networks (LANs). LAN A is illustrated as a wired LAN serving user device 112. LAN B is illustrated as a wireless LAN serving user device 113. It is envisioned that the LANs can be within the

coverage area of one of the base stations, and that handoff of user device 113 from the wireless LAN to the cellular network.

An exemplary user device 109 includes a radio transceiver 200 (FIG. 2) for communicating with a base station via a communication link 209. The transceiver 5 may be for a wired or wireless communication link, a single transceiver, such as a cellular telephone receiver or a data modulator/demodulator, or it may include multiple transceivers such as multiple cellular transceivers, or an 802.11 transceiver and a cellular radio transceiver, an Ethernet transceiver and a cellular transceiver, or any other combination of wired and wireless transceivers. A controller 202 includes 10 processing and memory 203 for controlling the user device operation. The controller may include a micro-controller and memory, and the memory may be volatile and/or non-volatile memory. As used herein, micro-controller can be implemented using any microprocessor, digital signal processor, programmable logic, discrete logic units, software processes, a combination thereof, or the like. The user device will typically 15 include user interface 204, such as a keypad, touch screen, speaker and microphone.

Those skilled in that art will recognize that the access network, which in the illustrated example includes base stations, will similarly include a transceiver 210 and controller 212, with memory 213, for communicating with user devices. The base station will include additional circuitry (not shown) for communicating with the RNC.

Operation of the user equipment, also referred to as user devices, (109-110) is 20 illustrated in FIG. 3. The user device 109 receives via transceiver 200 an acceptance message in step 302. This message may for example be received when the user device registers on the system 100. The acceptance message includes a rule set representing the desired behaviors for the user device, and the rule set is stored in memory 203 of 25 controller 202. It is envisioned that this rule set will be dependent upon the core network serving the device, and that the rule set will be temporarily stored in the device. Thereafter, the user device will receive broadcast messages through transceiver 200, as indicated in step 304. The broadcast message will include access information and may include updated rule sets. After receiving the broadcast 30 message, the controller 202 will compare the access information with the stored rule, as indicated in step 306. The controller 202 will determine if the access information in the broadcast message indicates a particular behavior, or if the rule set has been

updated. The controller 202 will control the user device to act according to the received access information as indicated in step 308. If an updated rule set is received, the controller 202 will store the updated rule information either by editing the rule set to include the changes, or store the new rule set in memory in place of the old rule set.

- 5 The behavior of the user device responsive to the access information will be according to the current rule set, which will be the previously stored rule set if no update has occurred or the updated rule set if the access information is communicated with an update.

The system will include a network element 400, which may be implemented
10 in memory 402 and a controller 404. The controller includes a micro-controller and is connected through a communication interface 406. The communication interface is any suitable interface facilitating communication between the controller and a network entity requiring translation between the core network information and the access network information, and thus facilitates communications with any part of the system
15 100. The memory 402 can be implemented using any suitable memory, which may be integrated with micro-controller 404 or discrete, and may be volatile or non-volatile. The network element 400 can be located in the core network 125, 126, the radio network controller 102, 103, the base stations 104-108, or other network entities (not shown, but the OMB of FIG. 6 for example). The network element 400 is, for
20 example, responsible for establishing a new connection to a user device, and establishing the rule set to be used by the communication device and the network in association with the communication device. The network element establishes respective rule sets for user devices connected to each core network, and thus can advantageously be implemented in the mobile switching centers and the SGSNs.
25 Alternatively, a rule set for a particular user device can be constructed at the radio network controller when a user device is registered on the system for a particular core network.

Operation of the network element 400 will now generally be described with respect to FIG. 5. The network element will establish a need to communicate with a target user device or user devices for a variety of different reasons, as is known in the art. It is envisioned, that when a user device 109-111 (FIG. 1) registers on the system 100, it will be assigned to one of the core networks 125, 126. At that time, the rule set

for the core network 125, 126 that will be connecting the user device will be communicated from the network element 400 to the user device. The communications interface 406 will receive an input, indicated at block 500, indicating that a particular user device requires a rule set, for example for establishing
5 registration on the system 100, or that a network entity requires the rule set, for example to contact a user device. The network element controller 404 thus provides (if rule is set is uniform for all associated devices when created such as where the network element resides in the core network for example), or constructs and communicates (if rule set is different for associated devices when created, such as
10 where the network element resides in the RNC and is constructed differently depending on whether the device will be associated for network A or network B for example), the rule set from memory 402, as indicated in step 502. If the rule set is to be changed, for example where the operator is altering the core network behavior, indicated in step 504, the user controller will provide an updated rule set as indicated
15 in block 506.

Alternatively to the network element mapping the rule set, it is envisioned that the rule set may be attached to a paging request communicated from the core networks 125, 126 to the access network. The access network can then apply the rule set to determine how the access core network information will be converted to access
20 network information.

A more particular example will now be described with reference to FIGs. 6-8. A shared radio access network 600, access networks, 130, 132, core networks 602 (does not include access networks 130, 132), and user device location identifications 604 are illustrated in FIG. 6. Each of the base stations broadcasts a location area identity (LAI) and routing area identity (RAI) that are pre-assigned. These may be referred to herein as location areas and routing areas, respectively. These are the shared access network location areas and routing areas, which are different in the illustrated example, but the base stations could alternatively broadcast routing areas and location areas that are the same. In the illustrated diagram, base stations 1-3
25 broadcast location area 1. Base stations 4-6 broadcast location area 2. Base stations 7-10 broadcast location area 3 and base stations 11-12 broadcast location area 4. Each of the base stations broadcasts a different, respective routing area. Although these
30

location areas are predetermined, the core networks 125, 126 may desire that different location areas and routing areas be provided for the user devices associated with the respective core networks. This presents a problem as the location areas are identified in broadcast messages, to all devices in communication with the user device, in GSM systems.

5 Operation of a user device 109 (FIG. 1) to receive dynamic location assignment will now be described with reference to FIG. 5. The user device 109 (FIG. 1) receives registration accept signal in step 702 from the base station 105 via transceiver 200 (FIG. 2). The registration accept signal, or message, may include the mapping information, or rule set to be used initially by the user device 109. This rule set and the access location identity, if present, are stored in memory 203 as indicated in step 704. Thereafter the user device 109 will receive broadcast messages via transceiver 200 as indicated in step 706. If the received access network location identity is different than the stored access network location identity, as determined in step 708, the controller 202 will map the access network location identity to the core network location identity, as indicated in step 710. The controller 202 will then compare the core network location identity stored in memory 203 to the newly mapped, or converted, core network location identity, to determine if it has changed as indicated in step 712. Only when the core network access identity has changed will the user device detect a cell change. The user device will then transmit the mapped core location identity to the core network in a location identity update signal, or message, as indicated in step 714. The user device will receive a location update acceptance message in step 716. This update may or may not include a rule set update. If not, the user device will wait to receive the next broadcast message in step 706 without updating the rule set in step 704. In the event that the location identity for the access network does not change, as determined in step 708, or the core network location identity does not change, as determined in step 712, the user device will return to wait for the next broadcast message in step 706.

10

15

20

25

30 It will be recognized by those skilled in the art that the controller 202 can map the received shared location identity to the core network location identity using a number of methods. One possible embodiment is converting the shared location identity using the rule set. It will also be recognized that location identity can be a

network identity for a wired system, and more particularly service set identifier (SSID) for LANs.

Location identities for wireless networks include location areas, used by the MSCs, and routing areas, used by the SGSNs. Thus, broadcasts of location areas 1 and 2 from the base stations BS1- BS6 will be mapped to location area 1 for user devices associated with MSC A, whereas user devices associated with MSC B will map broadcast location are 1 to location area1, and map location area 2 to location area 2. Similarly, user devices associated with core network A will map base stations BS7-BS12 location area transmissions to location area 2. User devices associated with MSC A will map base stations BS7-BS10 location areas to location area 3 and base station BS11 and BS12 location areas to location area 4. It will be recognized that the routing areas used for the SGSN A and SGSN B can be the same or different from the location areas. In the illustrated example of FIG. 6, user devices associated with SGSN A will map all of the respective routing areas from base station BS1-BS12 to routing area 1 for SGSN A, whereas user devices associated with SGSN B will map the routing areas from base station BS1-BS6 to routing area 1 and map routing areas from base stations BS7-BS12 to routing area 2.

In summary, the controller 202 will determine if the core network location identity has changed. In other words, when the user device moves from BS3 to BS 4 in FIG. 6, if MSC A serves the user device, the user device will treat it as no location change. If however, MSC B serves the user device, the user device will treat it as a location area change from location area 1 to location area 2. In the case of a user device served by MSC B, the core location identity will be updated and stored in memory 203, and the transceiver 200 will be used to transmit the new core location identity to the network through BS4. As a default, it is envisioned that where mapping information is not present (not provided to the user device), the user device will use the access network location areas as broadcast for the core network location identities. The user device will thus periodically perform cell re-selection uniquely for each core network. The rule set informs the user device how to associate the location areas of the radio access network with the desired unique location areas for the respective network operators.

The network will periodically determine if it is necessary to establish a connection with a registered device. For example, it may be necessary to page a user device to complete an incoming call. This process is described with respect to FIG. 8. When it is necessary to page the user device, as determined in step 802, the core 5 network will notify the network element 400. The controller 404 (FIG. 4) of the network element stores the last location for the target user device and will convey this to the radio network controller building the page message. The location area of the user device will be mapped to the location area for the radio network controller base stations, as indicated in step 806. The radio access network will be informed to 10 broadcast the page message to all of the base stations associated with the user devices location identity. Thus, for a user device in location area 1 and associated with MSC A, base stations BS1-BS6 will page the user devices. For user device in location area 1 and associated with MSC B, the page will be communicated only via base stations BS1-BS3. In this manner, the location identity rule set can be used. A network 15 element determines the last location area identity of the user device, and the stored rule set for the target user device in step 806. The rule set is used to determine which access network base stations are associated with the core network location areas for the particular core network trying to establish connection. Thus, the rule set will establish the access network base stations that will be requested to transmit the page in 20 step 808. The page will only be sent over the area mapped for the network operator, and the mapped area may be unique for each network operator even though the shared access network is used. This permits a shared network to be used by more than one network operator, providing a unique configuration defined for each network operator, without over burdening network resources.

25 Thus it can be seen that an improved methods and apparatus are disclosed. While this invention has been described with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. For example, various components of the embodiments may be interchanged, added, or substituted in the other embodiments. Various changes may 30 be made without departing from the spirit and scope of the invention.